The Consultative Committee for Space Data Systems

Draft Recommendation for
Space Data System Standards

TM SPACE DATA LINK PROTOCOL

DRAFT RECOMMENDED STANDARD

CCSDS 132.0-P-1.1

PINK SHEETS
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In accordance with standard data-communications practice, data fields are often grouped into eight-bit 'words' which conform to the above convention. Throughout this Recommendation, such an eight-bit word is called an 'octet'.

The numbering for octets within a data structure starts with zero. By CCSDS convention, all 'spare' bits shall be permanently set to '0'.

1.7 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommendation are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Recommendations.

[1] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1. 2nd ed. Geneva: ISO, 1994.

[2] *Information Technology—Open Systems Interconnection—Basic Reference Model—Conventions for the Definition of OSI Services*. International Standard, ISO/IEC 10731:1994. Geneva: ISO, 1994.

[3] *TM Synchronization and Channel Coding.* Recommendation for Space Data System Standards, CCSDS 131.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[4] *Space Link Identifiers*. Recommendation for Space Data System Standards, CCSDS 135.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, October 2006.

[5] *CCSDS Global Spacecraft Identification Field Code Assignment Control Procedures*. Recommendation for Space Data System Standards, CCSDS 320.0-B-5. Blue Book. Issue 5. Washington, D.C.: CCSDS, September 2007.

[6] *Space Packet Protocol.* Recommendation for Space Data System Standards, CCSDS 133.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[7] *Encapsulation Service*. Recommendation for Space Data System Standards, CCSDS 133.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, June 2006.

NOTE – Informative references are listed in annex B.

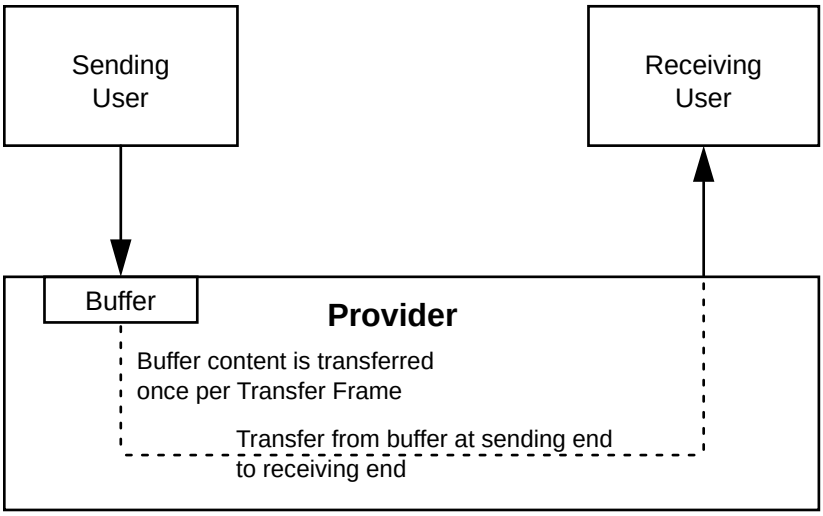

Figure 2-4: Synchronous Service Model

2.2.2.4 Periodic Service

Periodic service is a special case of synchronous service in which service data units are transferred at a constant rate. Periodic transfer from service interface to service interface is provided with a specified maximum delay and a specified maximum jitter at the service interface. There are three cases in which a synchronous service is periodic:

a) if the service is associated with a Virtual Channel (or a Master Channel), and that Virtual (or Master) Channel produces Transfer Frames at a constant rate, then the service is periodic;

b) if the service is associated with a Master Channel and there is only one Master Channel in the Physical Channel, then the service is periodic.

For periodic services, all service data units are sent only once if the user supplies service data units at the same rate as the rate at which the service provider transfers them.

2.2.3 SUMMARY OF SERVICES

2.2.3.1 General

Eight services are provided by the TM Space Data Link Protocol. Five of them (Virtual Channel Packet, Virtual Channel Access, Virtual Channel Frame Secondary Header, Virtual Channel Operational Control Field, and Virtual Channel Frame) are provided for a Virtual Channel. Three of them (Master Channel Frame Secondary Header, Master Channel Operational Control Field, and Master Channel Frame) are provided for a Master Channel. Table 2-1 summarizes these services.

Table 2-1: Summary of Services Provided by TM Space Data Link Protocol

Service	Service Type	Service Data Unit	SAP Address
Virtual Channel Packet (VCP)	Asynchronous	Packet	GVCID + Packet Version Number
Virtual Channel Access (VCA)	Asynchronous or Periodic	VCA_SDU	GVCID
Virtual Channel Frame Secondary Header (VC_FSH)	Synchronous or Periodic	FSH_SDU	GVCID
Virtual Channel Operational Control Field (VC_OCF)	Synchronous or Periodic	OCF_SDU	GVCID
Virtual Channel Frame (VCF)	Asynchronous or Periodic	Transfer Frame	GVCID
Master Channel Frame Secondary Header (MC_FSH)	Synchronous or Periodic	FSH_SDU	MCID
Master Channel Operational Control Field (MC_OCF)	Synchronous or Periodic	OCF_SDU	MCID
Master Channel Frame (MCF)	Asynchronous or Periodic	Transfer Frame	MCID
† The term 'Packet Service' is used as an abbreviation for Virtual Channel Packet (VCP) Service.			

2.2.3.2 Virtual Channel Packet (VCP) Service

The Virtual Channel Packet (VCP) Service transfers a sequence of variable-length, delimited, octet-aligned service data units known as Packets across a space link. The Packets transferred by this service must have a Packet Version Number (PVN) authorized by CCSDS. For the Packet Version Numbers presently authorized by CCSDS, see reference [4]. The service is unidirectional, asynchronous and sequence-preserving. It does not guarantee completeness, nor does it signal gaps in the sequence of service data units delivered to a receiving user.

A user of this service is a protocol entity that sends or receives Packets with a single PVN. A user is identified with the PVN and a GVCID. Different users (i.e., Packets with different versions) can share a single Virtual Channel, and if there are multiple users on a Virtual Channel, the service provider multiplexes Packets of different versions to form a single stream of Packets to be transferred on that Virtual Channel.

Only one user can use this service on a Master Channel, and the user is identified with the MCID of the Master Channel. Service data units from different users are not multiplexed together within one Master Channel.

The Master Channel Frame Service transfers the independently created TM Transfer Frames through the space link, together with TM Transfer Frames created by the service provider itself. This service is made available to trusted users who are certified during the design process to ensure that the independently created protocol data units do not violate the operational integrity of the space link. Necessarily, the independent Transfer Frames must have the same length as those generated by the service provider.

2.2.4 RESTRICTIONS ON SERVICES

There are some restrictions on the services provided on a Physical Channel:

a) if the Master Channel Frame Service exists on a Master Channel, other services shall not exist simultaneously on that Master Channel;

b) on one Master Channel, the Virtual Channel Frame Secondary Header Service shall not exist simultaneously with the Master Channel Frame Secondary Header Service;

c) on one Master Channel, the Virtual Channel Operational Control Field Service shall not exist simultaneously with the Master Channel Operational Control Field Service;

d) if the Virtual Channel Frame Service exists on a Virtual Channel, other services shall not exist simultaneously on that Virtual Channel;

e) on one Virtual Channel, the Virtual Channel Packet (VCP) Service shall not exist simultaneously with the Virtual Channel Access Service.

2.3 OVERVIEW OF FUNCTIONS

2.3.1 GENERAL FUNCTIONS

The TM Space Data Link Protocol transfers various service data units supplied by sending users encapsulated in a sequence of protocol data units using services of lower layers. The protocol data units, known as TM Transfer Frames, have a fixed length and must be transferred over a Physical Channel at a constant rate.

The protocol entity performs the following protocol functions:

a) generation and processing of protocol control information (i.e., headers and trailers) to perform data identification, loss detection, and error detection;

b) segmenting and blocking of service data units to transfer variable-length service data units in fixed-length protocol data units;

3 SERVICE DEFINITION

3.1 OVERVIEW

This section provides service definition in the form of primitives, which present an abstract model of the logical exchange of data and control information between the protocol entity and the service user. The definitions of primitives are independent of specific implementation approaches.

The parameters of the primitives are specified in an abstract sense and specify the information to be made available to the user of the primitives. The way in which a specific implementation makes this information available is not constrained by this specification. In addition to the parameters specified in this section, an implementation may provide other parameters to the service user (e.g., parameters for controlling the service, monitoring performance, facilitating diagnosis, and so on).

3.2 SOURCE DATA

3.2.1 SOURCE DATA OVERVIEW

NOTE – This subsection describes the service data units that are transferred from sending users to receiving users by the TM Space Data Link Protocol.

The service data units transferred by the TM Space Data Link Protocol are as follows:

a) Packet;

b) Virtual Channel Access Service Data Unit (VCA_SDU);

c) Frame Secondary Header Service Data Unit (FSH_SDU);

d) Operational Control Field Service Data Unit (OCF_SDU);

e) TM Transfer Frame.

3.2.2 PACKET

3.2.2.1 Packets shall be transferred over a space link via the Virtual Channel Packet (VCP) Service.

3.2.2.2 The Packets transferred by this service must have a Packet Version Number (PVN) authorized by CCSDS. Further, each Packet transferred must conform to the corresponding packet format specified by reference [4].

3.2.2.3 The position and length of the Packet Length Field of the Packets must be known to the service provider in order to extract Packets from Transfer Frames at the receiving end.

sending user may or may not be synchronized with the Virtual Channel or Master Channel. Such synchronization, if required for timing or other purposes, is a mission-design issue.

NOTE – Operational Control Field Service Data Units (OCF_SDUs) are fixed-length data units, each consisting of four octets, carried in the Operational Control Field (OCF), defined in 4.1.5, from a sending end to a receiving end. As defined in 4.1.5, CCSDS specifies the use of the first bit of this field to indicate the type of data carried.

3.2.6 TM TRANSFER FRAME

Transfer Frames transferred by the Virtual Channel Frame and Master Channel Frame Services shall be partially formatted TM Transfer Frames, and the following restrictions apply:

a) the Master Channel Frame Count Field of the Transfer Frames submitted to the Virtual Channel Frame Service shall be empty;

b) if the MC_FSH Service exists on a Master Channel, the Transfer Frame Secondary Header and the Transfer Frame Secondary Header Flag of the Transfer Frames submitted to the Virtual Channel Frame Service on the same Master Channel shall be empty;

c) if the MC_OCF Service exists on a Master Channel, the Operational Control Field and the Operational Control Field Flag of the Transfer Frames submitted to the Virtual Channel Frame Service on the same Master Channel shall be empty;

d) the Frame Error Control Field of the Transfer Frames submitted to the Master or Virtual Channel Frame Service shall be empty, if it is present on the Physical Channel.

NOTE – The TM Transfer Frame is the fixed-length protocol data unit of the TM Space Data Link Protocol, but also can be used as the service data units of the Virtual Channel Frame and Master Channel Frame Services. Its format is defined in 4.1 of this Recommendation. The length of any Transfer Frame transferred on a Physical Channel must be the same, and is established by management.

3.3 VIRTUAL CHANNEL PACKET (VCP) SERVICE

3.3.1 OVERVIEW OF ~~PACKET~~ VCP SERVICE

The Virtual Channel Packet (VCP) Service transfers a sequence of variable-length, delimited, octet-aligned service data units known as Packets across a space link. The Packets transferred by this service must have a Packet Version Number (PVN) authorized by CCSDS. For the Packet Version Numbers presently authorized by CCSDS, see reference [4]. The service is unidirectional, asynchronous and sequence-preserving. It does not guarantee

completeness, nor does it signal gaps in the sequence of service data units delivered to a receiving user.

A user of this service is a protocol entity that sends or receives Packets with a single PVN. A user is identified with the PVN and a GVCID. Different users (i.e., Packets with different versions) can share a single Virtual Channel, and if there are multiple users on a Virtual Channel, the service provider multiplexes Packets of different versions to form a single stream of Packets to be transferred on that Virtual Channel.

3.3.2 ~~PACKET~~VCP SERVICE PARAMETERS

3.3.2.1 General

The parameters used by the ~~Packet~~ (VCP) Service primitives shall conform to the specifications contained in subsections 3.3.2.2 through 3.3.2.5.

3.3.2.2 Packet

The Packet parameter shall contain a Packet for transfer by the ~~Packet~~VCP Service.

NOTE – The Packet parameter is the service data unit transferred by the ~~Packet~~VCP Service. For restrictions on the Packets transferred by the ~~Packet~~VCP Service, see 3.2.2.

3.3.2.3 GVCID

The GVCID parameter shall contain a GVCID that indicates the Virtual Channel through which the Packet is to be transferred.

NOTE – The GVCID parameter is part of the SAP address of the ~~Packet~~VCP Service.

3.3.2.4 Packet Version Number

NOTE – The Packet Version Number parameter is part of the SAP address of the ~~Packet~~VCP Service and identifies the protocol entity of the upper layer that uses the ~~Packet~~VCP Service.

3.3.2.5 Packet Quality Indicator

3.3.2.5.1 The Packet Quality Indicator is an optional parameter that may be used to notify the user at the receiving end of the ~~Packet~~VCP Service whether the Packet delivered by the primitive is complete or partial.

3.3.2.5.2 This parameter shall be used when the service provider is required to deliver incomplete Packets to the user at the receiving end.

3.3.3 ~~PACKET~~VCP SERVICE PRIMITIVES

3.3.3.1 General

The service primitives associated with the ~~Packet~~VCP Service are:

a) PACKET.request;

b) PACKET.indication.

3.3.3.2 PACKET.request

3.3.3.2.1 Function

At the sending end, the ~~Packet~~VCP Service user shall pass a PACKET.request primitive to the service provider to request that a Packet be transferred to the user at the receiving end through the specified Virtual Channel.

NOTE – The PACKET.request primitive shall be the service request primitive for the ~~Packet~~VCP Service.

3.3.3.2.2 Semantics

The PACKET.request primitive shall provide parameters as follows:

PACKET.request	(Packet, GVCID, Packet Version Number)

3.3.3.2.3 When Generated

The PACKET.request primitive shall be passed to the service provider to request it to send the Packet.

3.3.3.2.4 Effect On Receipt

Receipt of the PACKET.request primitive shall cause the service provider to transfer the Packet.

3.3.3.2.5 Additional Comments

The PACKET.request primitive shall be used to transfer Packets across the space link on the specified Virtual Channel.

3.3.3.3 PACKET.indication

3.3.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass a PACKET.indication to the ~~Packet~~VCP Service user ~~at the receiving end~~ to deliver a Packet.

NOTE – The PACKET.indication primitive shall be the service indication primitive for the ~~Packet~~VCP Service.

3.3.3.3.2 Semantics

The PACKET.indication primitive shall provide parameters as follows:

PACKET.indication	(Packet, GVCID, Packet Version Number, Packet Quality Indicator (optional))

3.3.3.3.3 When Generated

The PACKET.indication primitive shall be passed from the service provider to the ~~Packet~~VCP Service user at the receiving end to deliver a Packet.

3.3.3.3.4 Effect On Receipt

The effect of receipt of the PACKET.indication primitive by the ~~Packet~~VCP Service user is undefined.

3.3.3.3.5 Additional Comments

The PACKET.indication primitive shall be used to deliver Packets to the ~~Packet~~VCP Service user identified by the GVCID and Packet Version Number. Incomplete Packets may be delivered (optional).

3.4.3.2.5 Additional Comments

The VCA.request primitive shall be used to transfer VCA_SDUs across the space link on the specified Virtual Channel.

3.4.3.3 VCA.indication

3.4.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass a VCA.indication to the VCA Service user ~~at the receiving end~~ to deliver a VCA_SDU.

NOTE – The VCA.indication primitive shall be the service indication primitive for the VCA Service.

3.4.3.3.2 Semantics

The VCA.indication primitive shall provide parameters as follows:

VCA.indication	(VCA_SDU, VCA Status Fields, GVCID, VCA_SDU Loss Flag (optional))

3.4.3.3.3 When Generated

The VCA.indication primitive shall be passed from the service provider to the VCA Service user at the receiving end to deliver a VCA_SDU.

3.4.3.3.4 Effect On Receipt

The effect of receipt of the VCA.indication primitive by the VCA Service user is undefined.

3.4.3.3.5 Additional Comments

The VCA.indication primitive shall be used to deliver VCA_SDUs to the VCA Service user identified by the GVCID.

3.5 VIRTUAL CHANNEL FRAME SECONDARY HEADER (VC_FSH) SERVICE

3.5.1 OVERVIEW OF VC_FSH SERVICE

The Virtual Channel Frame Secondary Header (VC_FSH) Service provides synchronous transfer of fixed-length data units in the Transfer Frame Secondary Header (FSH) of Transfer

b) VC_FSH.indication.

3.5.3.2 VC_FSH.request

3.5.3.2.1 Function

At the sending end, the VC_FSH Service user shall pass a VC_FSH.request primitive to the service provider to request that an FSH_SDU be transferred to the user at the receiving end through the specified Virtual Channel.

NOTE – The VC_FSH.request primitive shall be the service request primitive for the VC_FSH Service.

3.5.3.2.2 Semantics

The VC_FSH.request primitive shall provide parameters as follows:

VC_FSH.request	(FSH_SDU, GVCID)

3.5.3.2.3 When Generated

The VC_FSH.request primitive shall be passed to the service provider to request it to send the FSH_SDU.

3.5.3.2.4 Effect On Receipt

Receipt of the VC_FSH.request primitive shall cause the service provider to transfer the FSH_SDU.

3.5.3.2.5 Additional Comments

The VC_FSH.request primitive shall be used to transfer FSH_SDUs across the space link on the specified Virtual Channel.

3.5.3.3 VC_FSH.indication

3.5.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass a VC_FSH.indication to the VC_FSH Service user ~~at the receiving end~~ to deliver an FSH_SDU.

NOTE – The VC_FSH.indication primitive shall be the service indication primitive for the VC_FSH Service.

NOTE – The VC_OCF.request primitive is the service request primitive for the VC_OCF Service.

3.6.3.2.2 Semantics

The VC_OCF.request primitive shall provide parameters as follows:

VC_OCF.request	(OCF_SDU, GVCID)

3.6.3.2.3 When Generated

The VC_OCF.request primitive shall be passed to the service provider to request it to send the OCF_SDU.

3.6.3.2.4 Effect On Receipt

Receipt of the VC_OCF.request primitive shall cause the service provider to transfer the OCF_SDU.

3.6.3.2.5 Additional Comments

The VC_OCF.request primitive shall be used to transfer OCF_SDUs across the space link on the specified Virtual Channel.

3.6.3.3 VC_OCF.indication

3.6.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass a VC_OCF.indication to the VC_OCF Service user ~~at the receiving end~~ to deliver an OCF_SDU.

NOTE – The VC_OCF.indication primitive is the service indication primitive for the VC_OCF Service.

3.6.3.3.2 Semantics

The VC_OCF.indication primitive shall provide parameters as follows:

VC_OCF.indication	(OCF_SDU, GVCID, OCF_SDU Loss Flag (optional))

3.7.3.2.3 When Generated

The VCF.request primitive shall be passed to the service provider to request it to send the Frame.

3.7.3.2.4 Effect On Receipt

Receipt of the VCF.request primitive shall cause the service provider to transfer the Frame.

3.7.3.2.5 Additional Comments

The VCF.request primitive is used to transfer Transfer Frames of a Virtual Channel across the space link.

3.7.3.3 VCF.indication

3.7.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass a VCF.indication to the VCF Service user ~~at the receiving end~~ to deliver a Frame.

NOTE – The VCF.indication primitive is the service indication primitive for the VCF Service.

3.7.3.3.2 Semantics

The VCF.indication primitive shall provide parameters as follows:

VCF.indication	(Frame, GVCID, Frame Loss Flag (optional))

3.7.3.3.3 When Generated

The VCF.indication primitive shall be passed from the service provider to the VCF Service user at the receiving end to deliver a Frame.

3.7.3.3.4 Effect On Receipt

The effect of receipt of the VCF.indication primitive by the VCF Service user is undefined.

3.8.3.2.5 Additional Comments

The MC_FSH.request primitive shall be used to transfer FSH_SDUs across the space link on the specified Master Channel.

3.8.3.3 MC_FSH.indication

3.8.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass an MC_FSH.indication to the MC_FSH Service user ~~at the receiving end~~ to deliver an FSH_SDU.

NOTE – The MC_FSH.indication primitive is the service indication primitive for the MC_FSH Service.

3.8.3.3.2 Semantics

The MC_FSH.indication primitive shall provide parameters as follows:

MC_FSH.indication	(FSH_SDU, MCID, FSH_SDU Loss Flag (optional))

3.8.3.3.3 When Generated

The MC_FSH.indication primitive shall be passed from the service provider to the MC_FSH Service user at the receiving end to deliver an FSH_SDU.

3.8.3.3.4 Effect On Receipt

The effect of receipt of the MC_FSH.indication primitive by the MC_FSH Service user is undefined.

3.8.3.3.5 Additional Comments

The MC_FSH.indication primitive shall be used to deliver FSH_SDUs to the MC_FSH Service user identified by the MCID.

3.9.3.3 MC_OCF.indication

3.9.3.3.1 Function

At the ~~sending~~receiving end, the service provider shall pass an MC_OCF.indication to the MC_OCF Service user ~~at the receiving end~~ to deliver an OCF_SDU.

NOTE – The MC_OCF.indication primitive is the service indication primitive for the MC_OCF Service.

3.9.3.3.2 Semantics

The MC_OCF.indication primitive shall provide parameters as follows:

MC_OCF.indication (OCF_SDU,
MCID,
OCF_SDU Loss Flag (optional))

3.9.3.3.3 When Generated

The MC_OCF.indication primitive shall be passed from the service provider to the MC_OCF Service user at the receiving end to deliver an OCF_SDU.

3.9.3.3.4 Effect On Receipt

The effect of receipt of the MC_OCF.indication primitive by the MC_OCF Service user is undefined.

3.9.3.3.5 Additional Comments

The MC_OCF.indication primitive shall be used to deliver OCF_SDUs to the MC_OCF Service user identified by the MCID.

3.10 MASTER CHANNEL FRAME (MCF) SERVICE

3.10.1 OVERVIEW OF MCF SERVICE

The Master Channel Frame (MCF) Service provides transfer of a sequence of fixed-length TM Transfer Frames of a Master Channel, created by an independent protocol entity, across a space link. The service is unidirectional, either asynchronous or periodic, and sequence-preserving. The service does not guarantee completeness, but it may signal gaps in the sequence of service data units delivered to a receiving user.

3.10.3.3 MCF.indication

3.10.3.3.1 Function

At the ~~sending~~receiving end, the service provided shall pass an MCF.indication to the MCF Service user ~~at the receiving end~~ to deliver a Frame.

NOTE – The MCF.indication primitive is the service indication primitive for the MCF Service.

3.10.3.3.2 Semantics

The MCF.indication primitive shall provide parameters as follows:

MCF.indication	(Frame, MCID, Frame Loss Flag (optional))

3.10.3.3.3 When Generated

The MCF.indication primitive shall be passed from the service provider to the MCF Service user at the receiving end to deliver a Frame.

3.10.3.3.4 Effect On Receipt

The effect of receipt of the MCF.indication primitive by the MCF Service user is undefined.

3.10.3.3.5 Additional Comments

The MCF.indication primitive shall be used to deliver Transfer Frames of a Master Channel to the VCF Service user identified by the MCID.

3 If the last Packet in the Transfer Frame Data Field of Transfer Frame *N* spills over into Frame *M* of the same Virtual Channel (*N*<*M*), the First Header Pointer in Frame *M* ignores the residue of the split Packet and indicates the start of the next Packet that starts in Frame *M*.

4.1.2.7.6.4 If no Packet starts in the Transfer Frame Data Field, the First Header Pointer shall be set to '11111111111'.

NOTE – The above situation may occur if a long Packet extends across more than one Transfer Frame.

4.1.2.7.6.5 If a Transfer Frame contains only Idle Data in its Transfer Frame Data Field, the First Header Pointer shall be set to '11111111110'.

NOTE – A Transfer Frame with its First Header Pointer set to '11111111110' is called an Only Idle Data (OID) Transfer Frame, meaning that it has Only Idle Data in its Data Field (see 4.1.4.6).

4.1.3 TRANSFER FRAME SECONDARY HEADER

4.1.3.1 General

4.1.3.1.1 If present, the Transfer Frame Secondary Header shall follow, without gap, the Transfer Frame Primary Header.

4.1.3.1.2 The Transfer Frame Secondary Header is optional; its presence or absence shall be signaled by the Transfer Frame Secondary Header Flag in the Transfer Frame Primary Header (see 4.1.2.7.2).

4.1.3.1.3 The Transfer Frame Secondary Header shall consist of an integral number of octets as follows:

a) Transfer Frame Secondary Header Identification Field (1 octet, mandatory);

b) Transfer Frame Secondary Header Data Field (1 to 63 octets, mandatory).

4.1.3.1.4 If present, the Transfer Frame Secondary Header shall be associated with either a Master Channel or a Virtual Channel.

NOTE – The association of a Transfer Frame Secondary Header with a Master Channel allows data to be transferred synchronized with this Master Channel. The association of a Transfer Frame Secondary Header with a Virtual Channel allows data to be transferred synchronized with this Virtual Channel.

4.1.3.1.5 If present, this field shall occur within every Transfer Frame transmitted through the associated Master or Virtual Channel throughout a Mission Phase.

4.1.4.5 If Packets are contained in the Transfer Frame Data Field, Packets shall be inserted contiguously and in forward order into the Transfer Frame Data Field.

NOTE – The first and last Packets of the Transfer Frame Data Field are not necessarily complete, since the first Packet may be a continuation of a Packet begun in the previous Transfer Frame, and the last Packet may continue in the subsequent Transfer Frame of the same Virtual Channel.

4.1.4.6 In the case where sufficient data (Packets including Idle Packets or a VCA_SDU) are not available to be inserted in a Transfer Frame Data Field at release time for a Transfer Frame, a Transfer Frame with a Data Field containing only Idle Data shall be transmitted. Such a Transfer Frame is called an OID (Only Idle Data in its Data Field) Transfer Frame. The First Header Pointer of an OID Transfer Frame shall be set to '11111111110' (see 4.1.2.7.6) and a project-specified 'idle' pattern shall be inserted into the Transfer Frame Data Field. The VCID of an OID Transfer Frame shall be one of the VCIDs used for transferring Packets.

NOTES

~~1 OID Transfer Frames are sent to maintain synchronous transmission of Transfer Frames and also to transmit data in the Transfer Frame Secondary Header and/or the Operational Control Field on a specific Virtual or Master Channel when there is no Packet to send.~~

1 The data field of an OID Frame contains only idle data, but the Transfer Frame Secondary Header or Operational Control Field potentially contains valid data depending upon the Virtual Channel ID.

2 OID Transfer Frames may be sent on Virtual Channels that also carry valid Packets, but it is preferred that a separate Virtual Channel be dedicated to carry ~~Idle~~OID Transfer Frames unless there is a need to send ~~Idle~~OID Transfer Frames on a specific Virtual Channel (e.g., to transmit data in the Transfer Frame Secondary Header and/or the Operational Control Field on a specific Virtual Channel).

3 An OID Transfer Frame can be generated whenever it is necessary (even in the middle of transmission of a Packet that is split into multiple Transfer Frames).

4 OID Data in the Transfer Frame Data Field of an OID Transfer Frame should not be confused with the Idle Packet specified in reference [6].

5 The idle pattern used in the OID Transfer Frame is project specific, but a random pattern is preferred. Problems with the reception of frames have been encountered because of insufficient randomization.

define the use of Type-2-Reports; however, it reserves the possibility to do so in future issues by restricting the utilization of the first bit.

4.1.6 FRAME ERROR CONTROL FIELD

4.1.6.1 General

4.1.6.1.1 If present, the Frame Error Control Field shall occupy the two octets following, without gap, the Operational Control Field if this is present, or the Transfer Frame Data Field, if an Operational Control Field is not present.

4.1.6.1.2 The Frame Error Control Field is optional; its presence or absence shall be established by management.

4.1.6.1.3 If present, the Frame Error Control Field shall occur within every Transfer Frame transmitted within the same Physical Channel throughout a Mission Phase.

NOTES

1 The purpose of this field is to provide a capability for detecting errors which may have been introduced into the Transfer Frame during the transmission and data handling process.

2 Whether this field should be used on a particular Physical Channel shall be determined based on the mission requirements for data quality and the selected options for the underlying Channel Coding Sublayer. This field may be mandatory depending on the selected options for the Channel Coding Sublayer.

4.1.6.2 Frame Error Control Field Encoding Procedure

4.1.6.2.1 The Frame Error Control Field is computed by applying Cyclic Redundancy Check (CRC) techniques. The Encoding Procedure shall accept an (n–16)-bit Transfer Frame, excluding the Frame Error Control Field, and generate a systematic binary (n,n–16) block code by appending a 16-bit Frame Error Control Field as the final 16 bits of the codeblock, where n is the length of the Transfer Frame.

NOTE – The Bit Numbering Convention as specified in 1.6.3 is applicable below.

4.1.6.2.2 The equation for the contents of the Frame Error Control Field is:

$$FECF = [(X^{16} \cdot M(X)) + (X^{(n-16)} \cdot L(X))] \text{ modulo } G(X)$$

$$= P_0 \cdot X^{15} + P_1 \cdot X^{14} + P_2 \cdot X^{13} + \ldots + P_{14} \cdot X^{1} + P_{15} \cdot X^{0}$$

where

– all arithmetic is modulo 2;

– FECF is the 16-bit Frame Error Control Field with the first bit transferred being the most significant bit P_0 taken as the coefficient of the highest power of X;

– n is the number of bits in the encoded message;

– M(X) is the (n-16)-bit information message to be encoded expressed as a polynomial with binary coefficients, with the first bit transferred being the most significant bit M_0 taken as the coefficient of the highest power of X;

– L(X) is the presetting polynomial given by

$$L(X) = \sum_{i=0}^{15} X^i ;$$

G(X) is the generating polynomial given by

$$G(X) = X^{16} + X^{12} + X^5 + 1.$$

~~NOTE — The $X^{(n-16)} \cdot L(X)$ term has the effect of presetting the shift register to all '1' state prior to encoding.~~

NOTES

1 The $X^{(n-16)} \cdot L(X)$ term has the effect of presetting the shift register to all '1' state prior to encoding.

2 A possible FECF generator implementation is shown in figure 4-5. For each frame, the shift register cells are initialized to '1'. The ganged switch is in position 1 while the information bits are being transferred and in position 2 for the sixteen FECF bits.

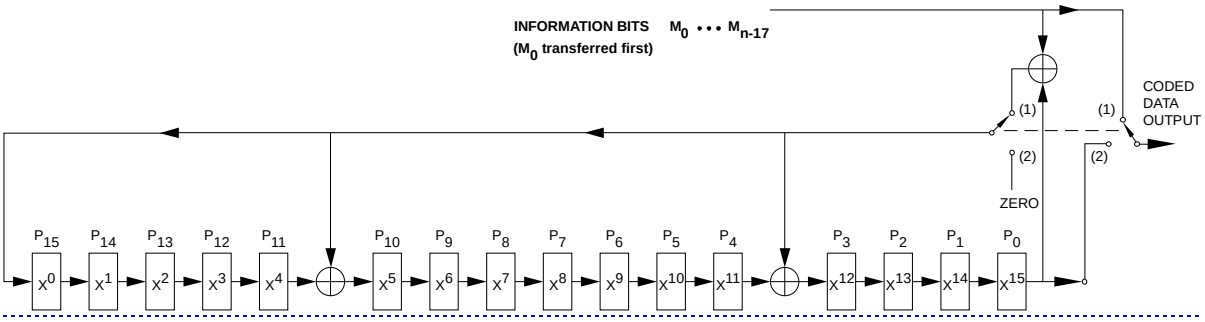

Figure 4-5: Logic Diagram of the Encoder

4.1.6.3 Frame Error Control Field Decoding Procedure

The error detection syndrome, S(X), is given by

$$S(X) = [(X^{16} \cdot C^*(X)) + (X^n \cdot L(X))] \text{ modulo } G(X)$$

where

– C*(*X*) is the received block, including the Frame Error Control Field, in polynomial form, with the first bit transferred being the most significant bit C_0* taken as the coefficient of the highest power of *X*; and

– S(*X*) is the syndrome polynomial which will be zero if no error is detected and non-zero if an error is detected, with the most significant bit S_0 taken as the coefficient of the highest power of *X*.

The received block C*(*X*) equals the transmitted codeblock C(*X*) plus (modulo two) the *n*-bit error block E(*X*), C*(*X*) = C(*X*) + E(*X*), where both are expressed as polynomials of the same form, i.e., with the most significant bit C_0 or E_0 taken as the binary coefficient of the highest power of *X*.

NOTE – A possible syndrome polynomial generator implementation is shown in figure 4-6. For each frame, the shift register cells are initialized to '1'. The frame includes *n*-bits, i.e., (*n*-16) information message bits plus the 16 bits of the FECF. All the *n* bits of the frame are clocked into the input and then the storage stages are examined. For an error-free block, the contents of the shift register cells will be 'zero'. A non-zero content indicates an erroneous block.

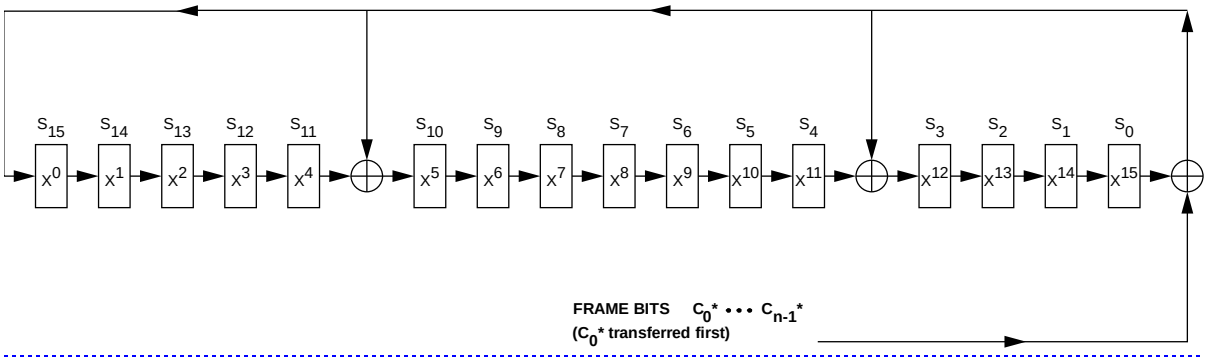

Figure 4-6: Logic Diagram of the Decoder

4.2 PROTOCOL PROCEDURES AT THE SENDING END

4.2.1 OVERVIEW

This subsection describes procedures at the sending end associated with each of the functions shown in figure 4-7. Data flow from the top to the bottom of the figure. This figure identifies data-handling functions performed by the protocol entity at the sending end and shows logical relationships among these functions. This figure is not intended to imply any hardware or software configuration in a real system. Depending on the services actually used for a real system, not all of the functions may be present in the protocol entity. The procedures described in this subsection are defined in an abstract sense and are not intended to imply any particular implementation approach of a protocol entity.

data shall be to create ~~an Idle Packet~~one or more Idle Packets of appropriate ~~length defined by reference [~~6~~].~~lengths, where an Idle Packet is either

– an Idle Packet defined by reference [6], or

– a Fill Encapsulation Packet defined by reference [7].

NOTE – The shortest Idle Packet defined by reference [6] is seven octets in length (i.e., a six-octet header plus one octet of idle data). If the area to be filled in a Data Field is less than seven octets, then the Idle Packet will spill over into the beginning of the next Frame Data Field. If it is necessary, the Packet Processing Function may generate an 'idle' Data Field by setting the First Header Pointer to '11111111110'. The shortest Idle Packet defined by reference [7] is one octet in length (i.e., a one-octet header).

4.2.2.6 If it is necessary, the Packet Processing Function may generate an 'idle' Data Field by setting the First Header Pointer to '11111111110'. An abstract model of the Packet Processing Function is illustrated in figure 4-8.

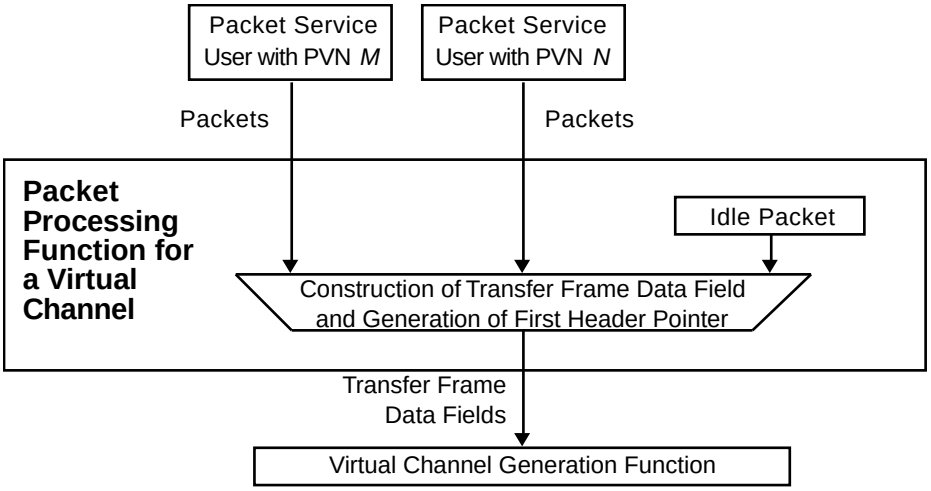

Figure 4-8: Abstract Model of Packet Processing Function

4.2.3 VIRTUAL CHANNEL GENERATION FUNCTION

NOTE – The Virtual Channel Generation Function is used to build the basic structure of Transfer Frames. It is also used to build the structure and the Primary Header of the Transfer Frames for transmission on each Virtual Channel. There is an instance of the Virtual Channel Generation Function for each Virtual Channel.

4.2.3.1 Transfer Frames shall be assembled by:

a) placing a Transfer Frame Data Field (received from the Packet Processing Function) or a VCA_SDU (received from the VCA Service user) into the Transfer Frame Data Field; and

NOTE – There is an instance of the Virtual Channel Multiplexing Function for each Master Channel that has multiple Virtual Channels.

4.2.4.2 The Virtual Channel Multiplexing Function shall multiplex Transfer Frames received from the instances of the Virtual Channel Generation Function and, if present, the Virtual Channel Frame Service users, and shall put them into a queue of Transfer Frames in an appropriate order that is set by management.

4.2.4.3 The algorithm used to order the Transfer Frames is not specified by CCSDS, but shall be defined by project organizations, considering factors such as priority, release rate, isochronous timing requirements, etc.

4.2.4.4 If there is only one Master Channel on the Physical Channel, the Virtual Channel Multiplexing Function shall create an OID Transfer Frame to preserve the continuity of the transmitted stream in the event that there are no valid Transfer Frames available for transmission at a release time. The OID Transfer Frame shall have its First Header Pointer set to '11111111110' and its VCID set to that of a Virtual Channel that carries Packets but does not support the VC_FSH or VC_OCF Service.

4.2.4.5 An abstract model of the Virtual Channel Multiplexing Function is illustrated in figure 4-10.

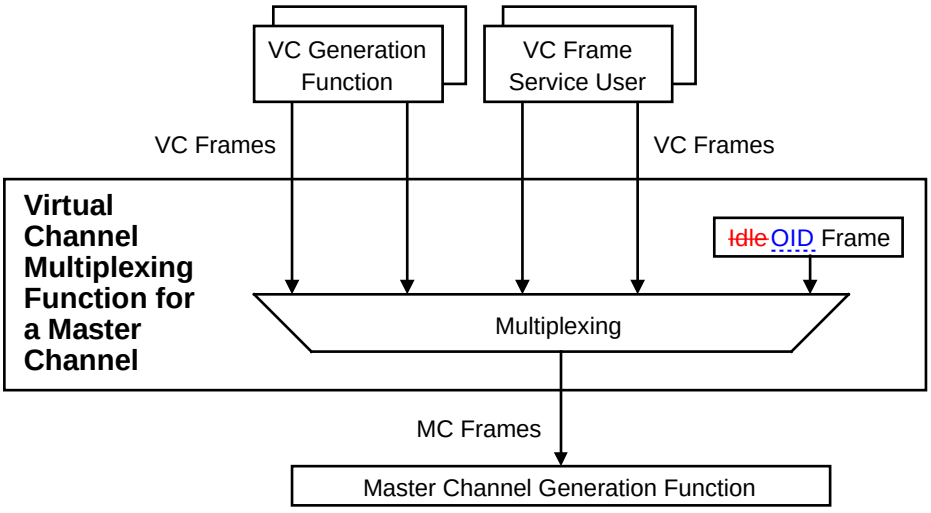

Figure 4-10: Abstract Model of Virtual Channel Multiplexing Function

4.2.5 MASTER CHANNEL GENERATION FUNCTION

4.2.5.1 The Master Channel Generation Function shall be used to insert Transfer Frame Secondary Header and/or Operational Control Field service data units into Transfer Frames of a Master Channel.

NOTE – There is an instance of the Master Channel Generation Function for each Master Channel.

4.2.6.4 The Master Channel Multiplexing Function shall create an OID Transfer Frame to preserve the continuity of the transmitted stream in the event that there are no valid Transfer Frames available for transmission at a release time.

NOTE – The OID Transfer Frame has its First Header Pointer set to '11111111110', and its MCID and VCID set to those of a Virtual Channel that carries Packets but does not have the Transfer Frame Secondary Header or the Operational Control Field.

4.2.6.5 An abstract model of the Master Channel Multiplexing Function is illustrated in figure 4-12.

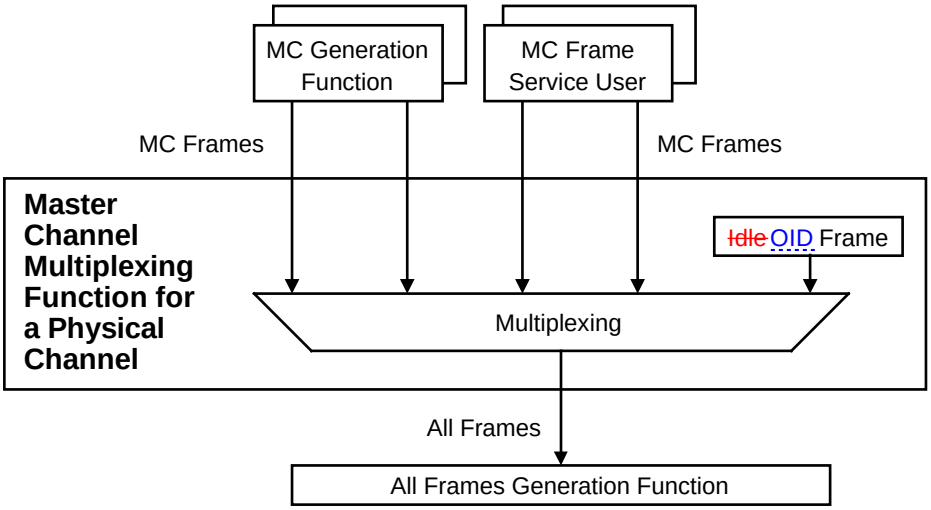

Figure 4-12: Abstract Model of Master Channel Multiplexing Function

4.2.7 ALL FRAMES GENERATION FUNCTION

4.2.7.1 The All Frames Generation Function shall be used to perform error control encoding defined by this Recommendation.

NOTE – There is an instance of the All Frames Generation Function for each Physical Channel.

4.2.7.2 If the Frame Error Control Field is present, check bits shall be generated using the encoding procedure described in 4.1.6.2 and inserted into the Transfer Frame Trailer.

NOTE – If this field is present, it must be present in all the Transfer Frames transmitted in a particular Physical Channel.

4.2.7.3 An abstract model of the All Frames Generation Function is illustrated in figure 4-13.

5.4 MANAGED PARAMETERS FOR PACKET TRANSFER

Table 5-4 lists the managed parameters associated with a Virtual Channel used for the Virtual Channel Packet ~~Transfer~~ Service.

Table 5-4: Managed Parameters for Packet Transfer

Managed Parameter	Allowed Values
Transfer Frame Version Number	1
Spacecraft ID	Integer
VCID	0, 1, …, 7
Valid Packet Version Numbers	Set of Integers selected from Table 7-6 of reference [4]
Maximum Packet Length (octets)	Integer
Whether incomplete Packets are required to be delivered to the user at the receiving end	Required, Not required

C3 TERMINOLOGY CHANGES

Table C-1 list the terms that have been changed from reference [B3].

Table C-1: Mapping of Terms of Reference [B3] That Have Been Redefined

Terms Used in Reference [B3]	Terms Used in This Recommendation
Packet Transfer Service	Virtual Channel Packet Service
Privately Defined Data Transfer Service	Virtual Channel Access Service